"Energy Crisis Preparation:
Policies and Practicesfor the
Livestock, Dairy, and Poultry Industries"

by

Lawrence A. Duewer,
Harold B. Jones, Jr.,
and
Floyd A. Lasley

ESS Staff Report No. AGESS801211
National Economics Division
Economics and Statistics Service
U.S. Department of Agriculture
Washington, D.C. 20250

STAFF REPORT

NATIONAL
ECONOMICS
DIVISION

ECONOMICS
AND
STATISTICS
SERVICE

UNITED
STATES
DEPARTMENT OF
AGRICULTURE

"Energy Crisis Preparation:
Policies and Practices for the
Livestock, Dairy, and Poultry Industries"

by
Lawrence A. Duewer,
Harold B. Jones, Jr.,
and
Floyd A. Lasley

ESS Staff Report No. AGESS801211
National Economics Division
Economics and Statistics Service
U.S. Department of Agriculture
Washington, D.C. 20250

December 1980

"ENERGY CRISIS PREPARATION: POLICIES AND PRACTICES FOR THE LIVESTOCK, DAIRY, AND POULTRY INDUSTRIES." By Lawrence A. Duewer, Harold B. Jones, Jr., and Floyd A. Lasley; Animal Products Branch; National Economics Division; Economics and Statistics Service; U.S. Department of Agriculture. December 1980. ESS Staff Report No. AGESS801211.

ABSTRACT

Availability of energy, particularly petroleum-based fuels, is a serious national concern. A long run problem exists, and a more serious short run supply shortage is possible. Energy is an essential part of producing, processing, marketing, and distributing animal products. Specific policies and practices affecting energy usage in the animal products industry are examined. Short, intermediate, and long run conservation measures are identified. Planning for and meeting an energy crisis is discussed, along with three sets of guides or suggested policies relevant to the animal products industry.

Keywords: Animal products, beef, pork, poultry, dairy, energy, policy, conservation.

* *
* This paper was produced for limited *
* distribution outside the U.S. Department *
* of Agriculture. *
* *

CONTENTS

Preface

The Food and Agriculture Act of 1977 will expire in 1981. The new legislation will become the Nation's masterplan for agriculture until 1985. It could well influence the organization and operation of the food system for many years.

Along with the traditional concern over price and income policy, several new issues have emerged since 1977. of particular significance are such matters as inflation, energy, credit, conservation of our resource base, the increasing international role of U.S. agriculture, and the design and implementation of both domestic and international food assistance programs.

This report is a product of the ESS research agenda for the 1981 food and agriculture bill. Energy conservation is a world and national problem which is subject to much concern. A severe shortage of petroleum-based fuels arising from war, politicial action, or other events would disrupt supplies and affect our entire Nation. This paper singles out specific information and issues involved in energy consumption and proposes policies for the animal products industry. Preparations for a crisis and its potential effects are emphasized.

SUMMARY

Energy is an essential part of producing, processing, marketing, and distributing animal products. Most of these products must be refrigerated or processed to keep them from spoiling. Transportation is also a vital element in the animal products industry. Any restrictions on the availability of energy to the industry would have serious and immediate impacts on the production and marketing processes.

Direct energy use in the livestock, poultry, and dairy industries is less than 1 percent of total energy consumption in the United States. However, these industries could not exist without it. The animal products industry would be expected to cut back in energy usage if a petroleum-based fuel crisis were to occur in the United States.

Through conservation efforts the animal products industry has been reducing energy usage in the past and will probably continue to do so in the future. Thus, given some lead time a certain decrease in energy use will probably be achieved without decreasing production.

In the event of an unexpected shortage of petroleum-based fuels, a quick reduction in energy use would be needed. Conventional conservation measures could not be adopted fast enough to meet the crisis. This paper examines what could be done to prepare for and meet such a crisis situation. It concentrates on the animal products industry, although such a policy must be in the context of total U.S. energy policy.

The objectives of this paper are to identify energy usage in the livestock, poultry, and dairy industries and outline some conservation measures that could be instituted in short run, intermediate run, and long run situations. Only the short run measures could be implemented if an unexpected crisis were to occur, but with preliminary planning, several other measures might be already in process or adopted before the crisis, giving them greater potential for being used during a crisis.

It is particularly significant to note that in a short run crisis situation in petroleum-based fuels, a part of the solution could be a shift to electricity, coal, LP, and natural gas, substances which a long run energy program would be trying to conserve. However, these shifts would tend to widen the petroleum-based fuels shortage to other forms of energy and may precipitate a wider energy crisis. Most energy sources are in limited supply; particularly in the short run where renewable resources or domestic fossil fuels cannot be produced immediately.

Feed handling, use of farm vehicles, and brooding poultry use the most energy at the production level. Dairy processing uses more energy than does the processing of other animal products although meat and poultry plants also use substantial amounts of energy. All fuels for transportation activities are petroleum-based. Economies of scale have given larger operations lower energy requirements per unit of output, even though they have greater substitution of capital and energy for labor than most small volume firms.

Energy is used for many different operations in the animal products industry, for example: heating poultry houses, refrigerating meat cases in the retail store, pneumatically blowing feed, and transporting milk to markets. Many uses of energy are designed to save labor, while others preserve wholesomeness and quality. In an energy crisis the essential needs of an activity must be taken into consideration as well as how much energy will be saved. For instance, refrigeration of fresh meat and most animal products is essential. If it is not refrigerated, then all the other expenditures of energy are in vain. By the same token, if energy is not used to move the product from producer to consumer, then there would be no need of producing it.

The price of energy in recent years has motivated managers of firms and farms to examine their operations and conserve energy. Many have made fuel or equipment changes to reduce energy costs. Thus, energy use has already been significantly reduced in many operations. However, more changes will have to be made in the future to save energy. Various measures and practices are available to conserve energy but some may require fairly large capital expenditures for new equipment or buildings. Alternative energy sources may be a feasible way to reduc energy usage also. With the ever-increasing energy costs, new energy-efficient facilities and technology will be adopted as equipment wears out and/or remodeling occurs.

Conservation is generally an on-going process, but heavy energy-using activities should receive priority attention in a crisis. Some production activities with potential for energy conservation might include brooding, lighting, insulation, ventilation, vehicle use, and feed handling. Processing conservation measures might include heat exchange recovery , insulation, lighting, use of alternative fuels, boiler blowdown control, and use of energy-efficient equipment. Transportation measures include use of diesel rather than gas, improved routing, shipment consolidation, decreasing speeds, and improving driving practices.

Retailers, restaurants, institutions, and consumers all have a variety of conservation measures available including refrigeration defroster sensors, energy-saving appliances, grouping orders, or combining shopping trips. New technological advances may also save energy in the future. These might range from hot boning of beef to retort packaging. Alternative energy sources can also reduce the need for petroleum-based fuels.

Conservation measures can essentially achieve reduced energy use in the long run, but cannot eliminate or avoid a crisis. In a short run supply shortage situation, panic and hoarding would immediately take place at all levels and disruption of energy supplies would probably occur. This would disruption the flow of animal products to the consumer and create substantial changes in both energy and animal product prices.

With prior planning, however, a shortfall in energy supplies would be less disruptive. Changes could be made more easily and the uncertainty

of whether fuel would be available or not may be alleviated. Prices for energy items and animal products may increase, but the prices at different levels in the marketing channel would retain market relationships.

Direct Government intervention may be needed to implement the plans for an energy crisis even with prior planning. Policy recommendations which include rationing or other programs could be put into effect when the crisis occurred. If rationing were used, it could affect animal products production and price levels, but, because of foreknowledge, there would be less panic. Uncertainty may well be a bigger problem than the shortage, but with proper planning there should be less uncertainty. Prior planning could also result in policy decisions to maintain animal products production levels, decisions to let prices allocate energy use, or any number of other strategies. The key would be to make these decisions and inform the public before a possible crisis occurred.

There are three sets of guides, or suggestions that may help in crisis planning. The first involves general policy considerations that should be a part of the planning process. Briefly these are: energy conservation is a national problem; sacrifice is needed to conserve energy in a crisis; energy-saving adjustments require time to implement and be effective; previous conservation savings by a firm should be considered; most commodities have certain critical stages of production and marketing; allocation by price alone likely will not achieve maximum effectiveness or social well-being in a crisis; and, there is no single or unique way of effecting substantial fuel savings.

The second set of ideas include a listing of possible policy measures or energy saving practices that could be implemented either before or during a crisis. There are many possible conservation or policy measures ranging from general subsidies to producers or marketing firms in selected activities to specific suggestions such as increasing bird densities in poultry houses, and encouraging use of hot boning and boxed beef. There are also possible regulations or selective taxation policies which could discourage certain practices, or cut production in certain areas or individual firms which are deemed energy-inefficient. Some of these measures could be implemented now, while others would be available in a crisis.

The last list includes items which policymakers might consider specifically for the 1981 Farm Bill or similar legislation which could improve the capability of the food industry to continue to provide adequate supplies of food while conserving fuel. These are:

1. Finance energy-efficient buildings and equipment, trucks and motor vehicles, and alternative fuel sources at lower than market rates through traditional agricultural lending agencies such as Farm Credit Administration, Farmers Home Administration, or Agricultural Stabilization and Conservation Service.

2. Provide subsidies or grants for the design and development of more energy-efficient buildings and equipment in production and

processing operations. Agricultural agencies in cooperation with DOE could administer such programs.

3. Provide income tax credits for installation and adoption of energy-efficient equipment and methods of production on the farm and in the marketing process. This would have to be part of the Internal Revenue Service tax laws.

4. Deregulate existing ICC controls on mandatory truck routes and eliminate backhaul regulations to allow the food industry to utilize greater truck capacity and use the most effective route structures.

5. Require ICC to use a "cost of service" concept for establishing railroad grain rate structures rather than a "value of service" concept. This more flexible type rate structure would be applicable to other commodities also.

6. Provide and finance a system for technical assistance in agricultural production and marketing operations to be conducted by traditional agricultural agencies such as ASCS, Agricultural Extension Service, or others with wide-spread field offices.

7. Encourage additional research and development by private agencies and by traditional research agencies in agriculture, primarily land grant colleges and experiment stations, Agricultural Research in SEA, and Economics Research in ESS.

INTRODUCTION

The impressive yields and productivity of American agriculture are directly dependent upon high levels of energy inputs in farm production, processing, and distribution. Energy is so indispensable to modern agricultural production and processing that shortages will have direct impacts upon food cost and output levels.

The energy crisis has created a new era of concern for energy use and conservation in the U.S. economy. The food system accounted for 16.5 percent of the Nation's energy use in 1975, and farm production accounted for 2.9 percent. The food system's energy usage is similar to the food industry's share of GNP. Energy is used to reduce labor requirements and increase output and productivity in the food production and marketing system. The bill for direct energy plus energy invested in fertilizer and pesticide production was 8 percent of total farm production costs in 1975, or about $6 billion. Energy costs beyond the farm gate that year totaled almost $20 billion. The food processing industry alone accounted for 4.8 percent of total U.S. energy consumption in 1975 and about 30 percent of the direct energy consumed in the food system. Marketing and distribution of food (including restaurants and cafeterias) accounted for an additional 2.7 percent of the energy consumed in the U.S. economy[44].

A combination of factors has made apparent both the short and the long term energy problems with which this Nation must cope. Even though animal products industry usage of energy is small relative to the total

economy, and to total agricultural use, it is important in absolute terms. Use of energy for food production and distribution should be of high priority; nevertheless, given an energy crisis, the animal products industry would be expected to reduce usage.

Public policy can create changes in the food production and distribution system by following different tactics varying from: requiring changes by law or regulation, encouraging or facilitating change by incentives or subsidies, by following a course of passive indifference, or possibly even resisting or forbidding certain changes. This paper assumes that policy can affect the energy used to produce animal products, and that it will be applied in the form of price controls, enforced allocation programs, or incentives in the form of tax reduction or subsidies. Some of these measures may reduce output of certain products for an indefinite period, wheras others may not.

Various Government agencies and trade association groups have been organized to monitor energy use, conduct energy research, develop conservation measures, conduct educational programs, and establish guidelines for energy use. Some conservation manuals have been developed to help producers implement energy savings practices. Other reports have emphasized energy usage patterns, potential energy savings techniques, possible fuel substitutes, and energy allocation programs for crisis periods of short supplies. Most of this information, however, does not relate specifically to the red meat, dairy, and poultry industries. Even though these industries account for only a small proportion of total U.S. energy consumption, there would be a need to curtail usage and implement immediate conservation practices if a crisis situation were to arise in the near future. This study is concerned with identifying both long and short term measures which could be taken to conserve energy, but particularly addresses measures for use in short run crisis situations and policies which may be feasible to help implement these changes.

The objectives of this study are to: (1) briefly review estimates of current energy usage in the livestock, dairy, and poultry industries, (2) identify some conservation measures that could be instituted in short run, intermediate run, and long run situations, (3) suggest types of policy changes or regulations that could lead to implementation of energy saving alternatives or practices, and (4) in particular, suggest preparations required to effectively meet a crisis situation in petroleum-based fuels.

This paper also discusses some of the actions, adjustments, and impacts of an energy crisis precipitated by a significant shortfall of petroleum based fuels. It is possible that such a shortfall could develop rather quickly, and that time would seriously limit the Nation's ability to effect fuel savings through adjustments initiated after the shortfall became apparent. Thus, results that might occur if only minimal preparations are made to deal with a severe shortfall are contrasted with well planned, in place, contingency plans. These plans could include direct government intervention to force energy conservation, an allocation plan that would provide animal products

sufficient energy to maintain production levels, and a preplanned decision to allow market prices to allocate fuel supplies.

It is particularly significant to note that in a short run crisis situation in petroleum-based fuels a part of the solution can be a shift to electricity, coal, LP, and natural gas; substances which a long run energy program would be trying to conserve. However, these shifts would tend to spread the petroleum-based fuels shortage to other forms of energy and may precipitate a more widespread energy crisis.

ENERGY USAGE IN THE ANIMAL PRODUCTS INDUSTRY

Animal products make up a significant and important part of the national diet. More than 6 percent of total disposable income and one-third of all food expenditures are for animal products. Still, energy use in the animal products industry is small relative to the total energy use in the United States. Total energy used for production (table 1), processing (table 3), and transportation (table 4) of animal products is less than 1/2 quadrillion BTU's--less than 1 percent of total energy use in the U.S. At least as much energy is also used after the products reach the city where they are consumed--in homes, restaurants and institutions. Thus, there is considerable potential for energy conservation in the retailing, institutional, and home food preparation sectors of the economy.

Estimates of energy usage for production of animal products can be summarized either on an operation basis (table 1) or commodity basis (table 2). Feed handling and farm vehicles are the largest users of energy (and of petroleum-based fuels) in the production sector. The enterprises using the most total energy are as follows: beef-cows and calves; milk cows; hogs; beef-feedlot; and broilers. Energy use per dollar of production value gives a different ranking: sheep and lambs; turkeys; broilers; miscellaneous poultry; beef-cows and calves; hogs; milk cows; and laying hens.

Dairy products use the most energy in the animal products processing sector. The second highest usage is by the meat packing industry (table 3). Energy sources for transportation are all petroleum-based fuels (table 4). Transportation functions include interfarm movement, farm to processor, and processor to the city where consumed. Additional transportation would also be needed to get these products to the local retail store or restaurant and to homes.

Information in figures 1 and 2 and table 5 provide additional data on energy use by operation and by enterprise. For poultry, the largest percentage of energy is used in brooding, but for almost all other enterprises, the feed processing and distribution function and the farm travel and automobile functions use the largest amount of energy. Waste removal is the largest single energy user in dairy farming. The first place to look when a cutback is needed is usually those functions that use the most energy. If a 40 percent item can be reduced a third, more energy could be saved than if several small energy using functions were cut out altogether.

Table 1-- Energy and agriculture: summary of energy used for red meat, dairy and poultry production by operation, U.S., 1978 1/

Type of Operation	Gasoline 2/	Diesel 2/	Fuel oil	LP gas	Natural gas	Coal	Electricity	Total energy
	------ 1,000 gals.			------	Million cu. ft.	Tons	Million Kwh's	Billion Btu's
Lighting	-	-	-	-	-	-	1734	5914
Feed handling	120284	316904	-	29606	-	-	1110	65606
Waste disposal vehicles	91665	79759	-	12931	-	-	-	23756
Waste disposal machinery	-	-	679	6983	461	-	119	1639
Water supply	-	13923	-	-	-	-	1537	7174
Livestock handling	13763	1942	-	5719	-	-	-	2536
Space heating	-	1	-	54357	11	-	164	5761
Ventilation	-	-	-	-	-	-	2020	6892
Water heating	-	-	-	68220	-	-	946	9745
Milking	-	-	-	-	-	-	794	2708
Milk cooling	-	-	-	-	-	-	1301	4438
Egg handling	-	-	-	-	-	-	31	106
Brooding	-	-	9539	215600	4669	36522	-	27512
Farm vehicles	214474	62225	-	8777	-	-	-	36278
Farm auto-livestock	68891	-	-	-	-	-	-	8611
Other	95283	12527	-	1659	-	-	205	14505
Total livestock	604363	487283	10218	403845	5141	36522	9961	223179
Total crops	2911293	2820464	280651	1020990	134922	-	21948	1824843
Total agriculture	3515656	3307747	290869	1424835	140063	36522	31909	2048022

1/ Data include all energy used directly on the farm for crop and livestock production; numbers may not add up exactly due to rounding.

2/ Gasoline and diesel use reflect machinery complements and crop production technologies in 1978.

Source: Torgerson, David and Harold Cooper, Energy and U.S. Agriculture; 1974 and 1978, USDA, ESCS, Stat Bul No.632, Washington, D.C., April 1980.

Table 2--Energy and agriculture: summary of energy used by red meat, poultry, and dairy enterprises, U.S., 1974 1/

Type of livestock enterprise	Value of production 2/	Inventory 3/	Annual Production	Gasoline	Diesel	Fuel oil	LP gas	Natural gas
	Million dollars	Million head	Million units	1,000 gals.				Million cubic feet
Beef-cows & calves	14,907	45	42735 lbs	314160	175500	-	11317	-
Beef-feedlot	NA	24		76675	86362	-	-	10
Milk cows	9681	11	115402 lbs	218318	-	-	76506	-
Hogs	6863	86	20112 lbs	115074	79777	-	50188	-
Layers	3057	286	66040 eggs	13966	1760	522	5090	249
Pullets	NA	286	NA	22680	893	1206	23556	545
Broilers	2434	2991	11315 lbs	23214	-	6397	122274	2237
Turkeys	679	131	2424 lbs	9994	1578	479	42395	1162
Sheep & lambs	270	15	804 lbs	21802	6546	-	-	-
Misc. poultry	125	NA	NA	1482	-	213	1559	424
Total livestock	38,015	NA	NA	817365	352416	8817	332885	4625

(cont)

NA = Not available.
- = Less than .5 unit.

1/ Data includes all energy used directly on the farm for crop and livestock production purposes - field operations, irrigation, crop drying, mechanized feeding, space heating, farm business auto use, etc. Numbers may not add up exactly to totals due to rounding.

2/ Livestock listed in order of dollar value. The value of beef-feedlot is included in the value of beef-cows and calves. The value of chicken pullets is included in the value of chicken-layers.

3/ Hens represent average number of layers (1000). Turkeys, broilers, chickens represent number raised (1000).

4/ Cows and calves are combined with feedlots; layers are combined with pullets.

Source: ERS, USDA, Energy and U.S. Agriculture: 1974 Data Base, Volume 2: Commodity Series of Energy Tables, FEA and USDA, Washington, D.C.. April, 1977.

Table 2 (cont.)

Type of livestock enterprise	Coal	Electricity	Total energy	Energy per dollar of production 4/
	Tons	Million Kwh's	Billion Btu's	Btu's
Beef-cows & calves	-	346	66096	6150
Beef-feedlot	-	1143	25585	NA
Milk cows	-	5105	51981	5369
Hogs	-	2001	37149	5413
Layers	-	829	5639	3855
Pullets	6108	14	6146	NA
Broilers	18882	504	19974	8205
Turkeys	6212	67	7174	10566
Sheep & lambs	-	18	3703	13720
Misc. poultry	1523	2	854	6815
Total livestock	32725	10028	224291	5900

Table 3- Energy used in animal products processing industries by type of energy, U.S., 1975 1/

Product	Distillate oil	Residual oil	Coal	Natural gas	Electricity	Total energy
	-- 1,000 barrels	----	1,000 tons	Billion cubic feet	Million Kwh's	Billion Btu's
Meatpacking plants (SIC 2011)	687.9	427.9	227.8	36.2	3,801.4	70,969.6
Sausage and other prepared red meats (SIC 2013)	191.2	280.0	18.4	4.0	1,543.7	13,989.2
Poultry dressing plants (SIC 2016)	162.4	248.1	15.8	2.8	1,375.5	10,918.4
Poultry and egg processing (SIC 2017)	68.6	47.9	0.0	1.3	194.4	1,364.8
Dairy products (SIC 202)	1,279.5	1,257.9	33.7	40.5	5,612.8	92,124.0
Total animal products processing	2,389.6	2,261.8	295.7	84.8	12,527.8	189,366.0

1/ Source: Barton, John A and Lutton, Thomas J., Energy Accounting in the Food Processing Industry USDA, ESCS-51, April 1979.

Table 4--Energy used in selected animal products transportation functions by market level and product, U.S., 1977.

Level and product	Gasoline	Diesel	Total energy
	1,000 gals.	1,000 gals.	Billion Btu's
To processor			
Milk assembly	23,000	38,000	8,089
Feeder livestock	20,000	41,800	8,365
Slaughter livestock	14,000	54,000	9,449
Broilers and turkeys	6,000	22,000	3,872
Egg assembly	10,000	4,000	1,345
Processor to city where consumed			
Dairy products (SIC 202)	2/	50,000 2/	6,943
Meat products (SIC 201) 1/	2/	234,000 2/	32,760
Totals	73,000	443,800	70,823

1/ Includes poultry.

2/ The source used did not differentiate between gas and diesel. A certain portion of the diesel should probably be under gasoline.

Source: Barton, John A., Transportation Fuel Requirements in the Food and Fiber System, USDA, AER-444. Jan. 1980.

Table 5--Percentage of livestock enterprise energy used by production operation, U.S., 1974 1/

Operation	Beef cow-calf operation	Beef stock operation	Beef feedlot	Sheep and lambs	Hogs farrowed to finish	Hogs feeder pig production	Hogs feedlot
				Percent			
Lighting	0.53	0.12	5.46	0.35	0.91	0.67	0.64
Feed processing and distribution	46.00	23.20	39.86	20.72	11.09	33.78	22.43
Waste handling	1.71	1.45	8.97	2.40	7.77	12.26	22.08
Water supply	1.40	0.34	16.78	0.19	6.61	6.63	12.10
Assembly-handling	1.91	4.69	---	11.53	0.03	0.42	0.13
Space heat	0.24	---	0.04	.81	16.19	7.88	---
Ventilation	---	---	---	---	8.67	4.88	2.75
Water heating	---	---	---	---	0.05	0.42	0.59
General farm travel	25.47	45.74	18.89	57.65	30.65	18.93	24.86
Farm automobiles	13.02	23.38	9.65	6.35	16.92	10.46	13.73
Other	9.72	1.11	0.52	---	0.94	3.67	0.69
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

1/ Percentages based on all fuels and electricity converted into Btu equivalents.

Source: A Guide to Energy Savings for the Livestock Producer, U.S. Dept. of Agriculture and Federal Energy Administration, June 1977.

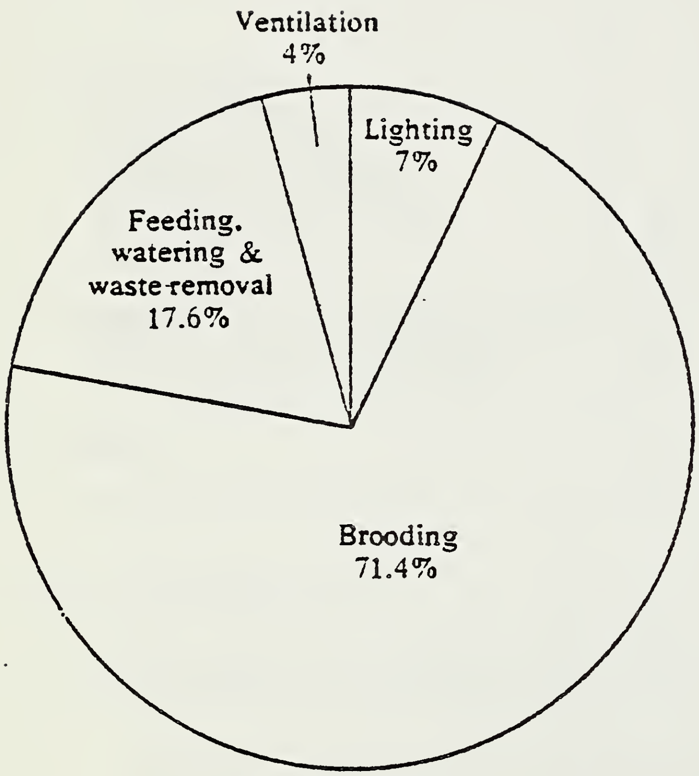

Figure 1. PERCENT OF THE BTU ENERGY USED IN POULTRY PRODUCTION THAT IS USED BY VARIOUS FUNCTIONS

Source: A Guide to Energy Savings for the Poultry Producer, U.S. Dept. of Agriculture and Federal Energy Administration, June 1977.

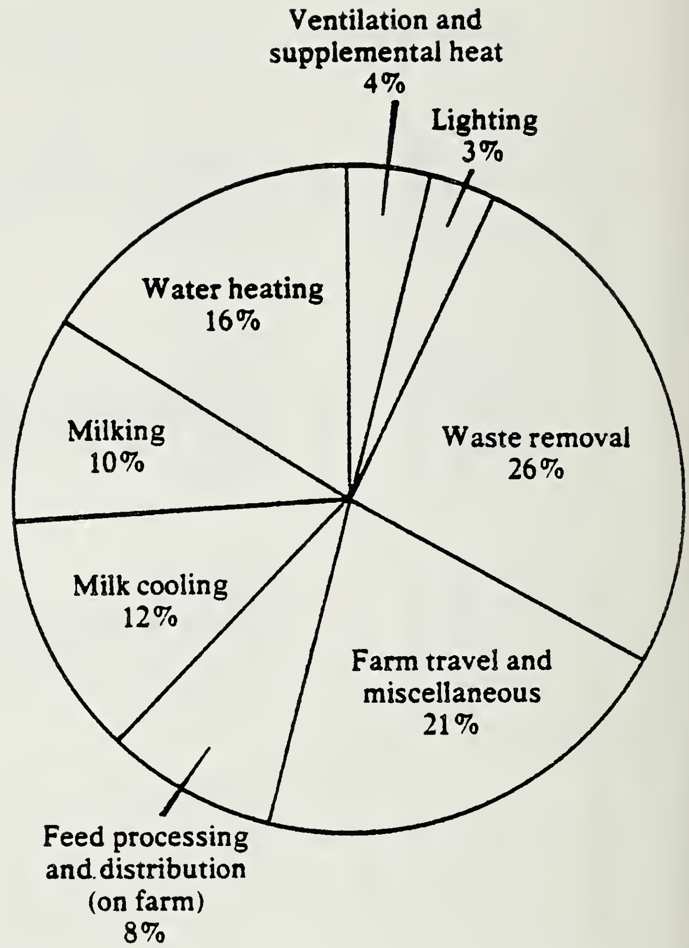

Figure 2 PERCENT OF THE BTU ENERGY USED IN DAIRY FARMING

Source: A Guide to Energy Savings for the Dairy Producer, U.S. Dept. of Agriculture and Federal Energy Administration, June 1977.

The relative amounts of the different types of energy used for livestock enterprises are given in table 6. Intensive hog operations tend to be the main user of LP gas, while almost all of the energy used for stocker cattle is gasoline for trucks used in feed distribution and checking the animals. Petroleum fuels are a large part of energy usage for livestock enterprises in total.

One source (Snell) divided meat packing energy use by function as follows: hot water accounts for 30 percent, processing 25 percent, refrigeration 15 percent, utilities 10 percent, transportation 5 percent, and boiler losses 15 percent [46].

All of these data have been taken from a variety of sources and some are for different years. Thus, they should not be regarded as precise figures, but only an approximate level of usage. Many participants in the animal products industry are aware of the energy problem and are adopting certain conservation measures. The meat packing industry is reported to have decreased energy usage by 27 percent from 1972 to 1973 [24]. Poultry industry conservation efforts may have effected a 15 percent savings in energy use during the 1974-79 period. Economies of scale can result in lower energy requirements per unit of output for the larger processing plants, even though they do have greater substitution of capital and energy for labor.

The increasing price of energy has motivated firms and farms to seek ways to reduce energy costs. There are many measures and practices available to conserve energy and more changes will be made in the future to save energy. Use of alternative energy sources is one method that may be feasible in certain situations. Other means of saving energy are dependent on large capital expenditures for new equipment, buildings, etc., and with the higher energy costs new energy saving facilities and technology will be implemented as equipment wears out and/or remodeling occurs.

This study is concerned with only that energy used in handling, producing, and marketing the livestock or meat, and not the indirect use of energy to produce inputs or resources in the livestock and meat industry.

CONSERVATION MEASURES

In the search for ways to conserve energy, an overall economic perspective must be maintained. Energy use has increased in order to help people do things better, or to substitute for labor or other resources. Conservation of energy is important, but it must be balanced against the possibility of a lower level of living. Conservation measures should be considered in view of how critical the shortage is and the possible inefficiencies, risks, and costs that could result from implementing the energy saving technique. Ideally, conservation measures should have a positive economic payoff over a period of time.

As energy becomes more expensive, conservation measures have become more important from an economic standpoint. Substantial opportunities are available for reducing energy usage and costs. A listing of possible

Table 6 -- Proportion of various types of energy used in production by type of livestock enterprise, U.S., 1974

Energy types	Beef cow-calf operation	Beef stock operation	Beef feedlot	Sheep and lambs	Hogs farrowed to finish	Hogs feeder pig production	Hogs feedlot
				Percent			
Gasoline	45.05	94.95	37.45	73.61	38.11	47.79	37.96
Diesel	50.45	4.33	47.26	24.74	28.20	31.07	44.84
LP Gas	2.19	0.24	---	---	14.87	6.66	---
Natural gas	---	---	0.04	---	---	---	---
Electricity	2.31	0.48	15.25	1.65	18.82	14.48	17.20
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: A Guide to Energy Savings for the Livestock Producer, U.S. Dept. of Agriculture and Federal Energy Administration, June 1977.

conservation measures has been made by industry level and specific measures are suggested in tables 7-13. Some conservation measures are commodity specific and others are applicable to more than one enterprise.

Certain measures listed probably would have some difficulty in being implemented. Many farms or firms already are using some of these measures and there are various other reasons why implementaion would be difficult. Some would require additional capital expenditures or a change in labor requirements. Often there is not space for the particular equipment or various practices would have to be adapted or changed. Some managers resist change because they don't want to disrupt current operations. Other conservation measures listed could be incompatible with present technology. In tables 7-13 on conservation measures, the time periods specified for implementation are: short run = 4 months or less; intermediate term = from 4 months to 18 months; and long run = longer than 18 months. In other sections of the tables the following terminology is used for certain items: small means less than 5 percent of total costs, total investment, total price, or total output (whichever is relevant); moderate means 5 to 15 percent; and substantial means more than 15 percent. The term immediate under payback period means that the conservation measure has a net saving as soon as it is implemented because no capital investment is required.

Production

Methods and production practices vary greatly among livestock, dairy, and poultry enterprises which means energy conservation measures will also vary substantially.

Poultry

The production of poultry products involves a wide range of environmental conditions and a variety of farm enterprises. Farms are specialized and are dispersed over wide geographic areas. Energy usage is highly variable depending upon farm type, location, and level of mechanization.

Brooding of poultry accounts for the largest single use of energy in the production process, about 71 percent of the total (Figure 1). Lighting accounts for 7 percent; feeding, watering, and waste removal about 18 percent; and ventilation about 4 percent. Rates of energy use per 1,000 birds will vary greatly, however, depending upon the types of birds, geographic location, and types of housing.

Energy use per head of poultry for production activities had shown some decline even before the energy crisis which began in 1974[30]. From the mid-1960's to the early 1970's more efficient use of heating fuels, particularly for broilers, was more than enough to offset larger quantities of electricity consumed as a result of the larger number of mechanized cage layer operations and increased numbers of confinement reared turkeys. Increased efficiency of energy use also occurred as a result of economies of large scale production, larger flocks, and increased density of many supply areas.

There are a wide variety of conservation measures that could be undertaken to achieve additional energy savings for individual producers. The potential for savings is substantial, depending upon the extent to which producers have already adopted certain practices. Table 7 presents some of the methods that could be used in reducing energy use and the approximate amount of savings they represent.

In the short run, achieving energy savings is a matter of attention to details and modifications of existing practices. These approaches often require very little capital expenditure relative to the potential dollar savings (Table 7). Good records that monitor energy usage by functions will help identify areas where conservation efforts may be useful.

The fuel used to heat poultry houses for broilers, layer replacements, or turkey poults accounts for most of the brooding energy used. Fuel consumption per bird can be decreased 20 to 50 percent by adopting certain energy conservation measures and by following good management practices [3,29]. Simple rules, such as locating brooders in the center of the house, using solid brooder guards (sheet metal or corrugated paper), clustering brooders in groups of three or four, and following manufacturer's preventive maintenance and adjustment procedures for brooding equipment, can save a producer energy.

Partial house brooding, by using a plastic curtain to partition a poultry house and brooding chicks during the first 3 weeks in only part of the house, can save as much as 25 percent of the energy used in brooding. Covering the side curtains with plastic during the winter can save 10 to 15 percent. Energy can also be saved by shutting off brooder pilot lights on some of the brooders as the birds grow older and require less supplemental heat.

Lighting of poultry houses is another operation in which energy can be saved. Electricity can be saved by reducing hours of light per day, using intermittent lighting schedules, adding reflectors to maximize use of light produced, using flourescent or mercury lamp lighting instead of incandescent bulbs where feasible, improving light location patterns, decreasing light intensity, and increasing use of sunlight.

Energy use can also be reduced by installing and properly maintaining the most efficient ventilation equipment. An indicator of fan efficiency is cubic feet per minute per watt. However, the efficiency of the ventilation system also depends on the total system design, as the system must provide an even distribution of fresh air while removing moisture, dust, and gases. Producers having poultry houses with an enclosed attic area may be able to save energy during the winter by drawing the incoming air from the attic, since the attic air is as much as 10° to 15°F warmer than the outside air.

Although energy used directly in feeding and watering poultry is relatively small, energy savings can be attained by reducing the number of feeding cycles on mechanical feeders and by properly adjusting and maintaining feeders and waterers. Water spillage requires more energy to

Table 7 -- Potential energy conservation measures for poultry production enterprises, U.S. 1/

Energy saving measures	Poultry type 2/	Type of energy	Time period to implement	Potential energy savings per 1,000 birds		Potential cost savings per 1,000 birds	Capital investment required per house		Payback period on investment	Description of practice
				Actual	Percent	- Dollars	-	Number birds		
Partial house brooding	B	LP-NG	Short run	14.21 gals	33	8.52	50	16,000	1 mo.	Plastic partitions
Winterize side curtains	B	LP-NG	Short run	11.99 gals	26	7.19	65	9,000	3 mos.	Plastic covers
Insulate broiler house roof	B	LP-NG	Short run	43.07 gals	50	25.84	4800	18,000	2 yrs.	Add 2 inches to roof
Insulate turkey brooder house	T	LP-NG	Short run	138.27 gals	36	82.96	5325	15,000	2 yrs.	Install roof insulation
Reduce lighting schedule	L	Elec.	Short run	243.00 KWH	28	12.17	None	--	--	Reduce hours of light
Lower light intensity	B	Elec.	Short run	99.36 KWH	60	4.97	150	14,000	5 mos.	Dimming lights
Improved ventilation system	L	Elec.	Short run	780.00 KWH	34	35.98	None	--	--	More efficient fans
Intermittent lighting system	B	Elec.	Short run	77.64 KWH	75	3.88	None	--	--	Environmental house
Reduce feeding cycles	B	Elec.	Short run	11.86 KWH	37	.59	None	--	--	Environmental house
Install light reflectors	L	Elec.	Short run	698.00 KWH	37	34.90	25	5,600	2 mos.	Plus smaller bulbs

1/ Based on data from Benson, V. W., A Guide to Energy Savings for the Poultry Producer, U.S. Dept. of Agriculture and Federal Energy Administration, Washington, D.C., June 1977; plus other sources [22, 30].

2/ Refers to B for broilers, T for turkeys, and L for laying hens.

handle additional water, and additional heat and ventilation to evaporate the spilled water and remove it from the house.

Long-run energy saving considerations are very important when designing new poultry housing or modifying existing housing. Houses should be designed to provide maximum comfort for the poultry and convenience for the operator at the lowest possible investment and operation cost.

Installation of insulation in existing poultry houses is expensive. However, at current prices the fuel savings attained from insulating a poultry house ceiling can be expected to exceed the cost plus interest over a 10-year period. The savings in fuel use in a properly insulated poultry house can be 50 percent or more, compared with fuel use in an uninsulated poultry house. With fuel prices still rising and oil supplies diminishing, the benefits, economic and otherwise, should increase over time and allow insulation to pay for itself in as few as 5 years.

Livestock

Conservation measures for the livestock producer centers around feeding practices and housing (Table 3). The less feed has to be changed (processed, ground, pelleted, etc.) and handled [17], the less energy is used. Even in the case of a cattle herd on the range, the fewer times and the shorter the distance supplements, winter feed, etc., need to be delivered, the less fuel is used. Sometimes there are other considerations besides energy, however, such as the need for checking cattle on the range at certain intervals, usually when feed is delivered.

For confinement type enterprises such as hogs the amount of insulation and the ventilation and heating systems will have an important effect on energy use. Use of fluorescent vs. other kinds of lighting, and reducing the number or intensity of lights can also conserve energy. Unless energy for the production of feed and equipment are included, energy usage by animals producing red meats is very small except for confinement hog production. A relatively large amount of energy used in livestock production is for trucking and transportation. Fewer or combined trips could save energy.

Producers of animal products also have the prospect of producing methane gas from the manure produced. Another possibility for the livestock producer might be the feeding of distillers grain residue (or other joint products) from alcohol production.

Dairy

Farm milk production, although a relatively heavy user of energy compared to most farm enterprises, may not be as sensitive to brief "outages" of power or fuel as is poultry. However, once produced, milk is highly perishable and must be moved through the marketing process within a short time. Temperature requirements are also rather exacting if quality is to

Table 8-- Potential energy conservation measures for livestock production enterprises, U.S.

Energy saving measures	Implementation time (S,I,L)	Potential energy savings	Potential cost-savings of measure	Effect on output	Effect on product price	Capital investment required	Payback period on investment
Feeding whole corn	S	4,000 BTU per bushel	All grinding or processing costs	---	---	None (reduces)	Immediate
Every 2 day feeding	S	½ of BTU's used in feeding	½ of previous costs	---	---	---	Immediate
Fencing and rotating pasture	S, I	Up to ½ of fuel	Fuel saving but fencing costs may increase	Small increase	Small decrease	Cost of fence	Year or more
General tractor and equipment usage	S	Proportional to decreased usage	Proportional to decreased usage	---	---	---	Immediate
General tractor and equipment fuel choice	I, L	Related to prices among fuels	Moderate in long run	---	---	Yes, when equipment replaced	2-3 years
Insulating buildings	S, I, L	Up to ½	1/3 to 1/2 fuel costs	Small	---	Substantial	2-3 years
Lighting changes	S, I	Small in LR	Moderate	---	---	Moderate	2-3 years
Feeding high moisture corn	I, L	Moderate in LR	In long run	---	---	Substantial	6 or more years

Source: Based upon material from various references.

be maintained. However, the risk of losing an occassional tank of milk is not as serious as the loss resulting from interruptions in the fuel or power supply to a poultry production unit during a critical phase of production. Cost and difficulty of handling very large herds during fuel or power outages make it advisable to provide an alternative or standby power source for emergencies.

Most of the energy used by milk producers is used on the larger operations. There were 351,970 farm operations with milk cows in 1979, but only 36.8 percent of these had as many as 30 cows. Nearly 90 percent of the milk marketed now comes from only 120,000 dairy farms. Farm conservation measures are related to feed handling, water heating, milk cooling, and barn ventilation.

Processing

A multitude of conservation measures are available to livestock, dairy, and poultry processing plants. The particular processing system, type of commodity, equipment components, and plant facilities currently in use will affect the particular conservation measures that can be put into operation. However, some energy saving measures will be similar in many plants.

It is evident from previous studies that efficiency of energy use in the processing and marketing sectors has gradually increased since the mid-1960's. In assembly operations energy efficiencies are a result of larger truck sizes with heavier gross vehicle loads and decreased mileage per load due to increased density of supply areas. Energy productivity has increased in processing due to economies of scale, higher utilization of plant capacity, and adoption of more efficient plant equipment. Increased efficiency in long distance transportation has been the result of larger vehicles with heavier pay loads and more efficient route structures for distribution of products. The trend toward more direct marketing channels has led to a decline in wholesaling operations for dairy, meat, poultry, and egg products, reducing energy needs of wholesalers. In the retailing sector, there has been a wider variety of product forms in recent years, but large scale retail stores and more efficient warehousing operations have tended to increase efficiency of energy use.

Economies of size often results in lower energy requirements per unit of output for the larger processing plants, even though they often substitute proportionally larger amounts of capital and energy for labor than do the smaller plants. These in-plant economies are especially significant in areas of heavy production where large volumes can be assembled without excessive transportation costs. However, fuel costs for assembling larger volumes in low-density production areas would generally outweigh the in-plant fuel savings of larger plants. Smaller plants, matched with smaller procurement areas, will often be more fuel efficient in low density production areas.

There are three main types of conservation measures that can be effective in reducing energy requirements of processing plants: (1)

Table 9 --Potential energy conservation measures for dairy production enterprises, U.S.

Farm production measures	Implementation time	Function cost per unit	Capital investment	Output effect	Payout period	Product price effect	Potential fossil energy savings on function
Use feedstuffs requiring low-fossil fuel input	Intermed.	Increase 8-12%	Small	Minor negative	NA	Increase	8-15% 30-50 mil. gal. gasoline equivalent
Water heating (solar heating, use heat from milk to preheat, separate heaters)	Intermed.	Reduce 10%	Small to $2,000/ farm	---	5-8 years	Small	15-20% 300-500 mil. KWH equivalent
Milk cooling pre-cool with water	Intermed.	Reduce 10%	Up to $1,000/ farm	---	5-8 years	Small	300-500 mil. KWH equivalent
Control barn ventilation (ventilation, insulate parlor)	Short	Reduce 15%	$500-1,000/ farm	---	2-5 years	---	200-400 mil. KWH equivalent

Source: Based upon material form various references.

short-term changes in plant management practices and monitoring devices, (2) alteration of existing equipment and processes, and (3) adoption of new plant and equipment that is more energy efficient or embodies radically new technology. Of the three possibilities, the first two have the greatest potential for immediate or short run benefits, whereas the third offers the most promise in the long run when new plants are being built or substantial renovations are needed. Tables 10, 11, and 12 list conservation measures for poultry, livestock and dairy processing plants.

Previous studies have indicated a number of ways to reduce energy consumption in meat, milk, and poultry processing plants. One important conservation measure involves the use of heat exchangers or heat reclamation systems for heating and cooling water or product [19,30]. Heat from the condensing side of refrigeration compressors could be used for space or water heating, and scald water could be used to preheat incoming water for further use in the plant. The ammonia used in large refrigeration systems typically reaches temperatures of 250° to 285°F at compressor discharge, and this could be used in heating hot water to 150° by a heat exchanger. A 200 ton refrigeration unit could preheat 650 to 900 gallons of hot water per hour which, for example, would be enough scald water for 3,600 broilers. An exchanger could save up to $12,000 annually in costs and also reduce fan capacity and water needed in the evaporative condenser with a savings of 50 percent in energy for these operations.

Another energy-saving possibility involves proper insulation of boilers and steam pipes plus steam traps to return condensate to the boilers. Savings of 10 to 20 percent or more may be possible [19, p.18]. Installation of new metal clad insulation would also eliminate the deterioration problem from high-pressure steam cleaning of insulated pipes, although initial costs would be higher for the metal clad insulation [30, p.37]. Insulation of pipes and cold surfaces in plants to reduce heat gain and minimize cold air transfer could also reduce electricity use with a payback on investment of 1 or 2 years. These measures are not very costly, and they could be implemented in a short period of time.

Additional energy savings could be realized by installing more elaborate equipment control systems that regulate temperature and/or efficiency of steam and hot water use. Such controls could result in energy savings of 10 percent or more depending upon the level of automation that already exists in plants [19, p.19]. Use of solenoid valves to control the flow of cooling water to air compressors may also reduce water costs. Surface temperature monitors located downstream from steam traps could indicate the relative effectiveness of these traps and also save energy. Preheated overflow water from scalders can be salvaged. Other types of control equipment may also be feasible in many plants.

Since fuel constitutes a high percent of in-plant energy use in processing (65 percent for poultry) proper design and optimum combustion of boilers is very important. Fuel savings of 10 to 20 percent are

Table 10 -- Potential energy conservation measures for poultry processing and marketing firms, U.S. 1/

Energy saving measures	Type of energy	Time period to implement	Potential energy savings		Potential cost savings	Capital investment required	Payback period on investment	Description of practice
			Units per hour	Percent	Dollars per year	Dollars per plant		
Heat reclamation exchange system	NG-FO	Intermediate	1.6 mil. BTU	50	12,000	12,300	1 yr.	Recover scald overflow water
Insulate boiler and steam pipes	NG-FO	Short run	937 BTU	24	3,200	3,400	1 yr.	--
Insulate cold and refrigerated surfaces	Elec.	Short run	--	--	2,320	2,300	1 yr.	Insulate chillers, install curtains at doors
Heat recovery refrigerated units	NG-FO	Intermediate	500,000 BTU	50	4,880	2,400	6 mos.	--
Steam condensate control system	NG-FO	Intermediate	--	10	4,000	--	--	Trap condensed steam for reuse
Improve boiler combustion	NG-FO	Short run	--	15	--	--	--	Improved controls and monitoring
Vapor recovery system	NG-FO	Intermediate	--	20	32,000	60,000	2 yrs.	Heat exchanger in rendering plants
Power suppressor controls	Elec.	Short run	600 KWH	15	9,000	--	--	--
Install power capacitors	Elec.	Intermediate	--	30	450	--	--	Improves power factor on motors
High efficiency motors	Elec.	Intermediate	--	25	--	--	--	--
Fluorescent or sodium lights	Elec.	Intermediate	6 KWH	74	500	1,800	4 yrs.	Replace incandescent lamps
Computer energy management	Elec.	Intermediate	--	15	--	--	--	Control and monitoring devices
Alternate fuel sources	NG-FO	Intermediate	--	36	62,000	--	--	Switch from fuel oil to natural gas
Automatic equipment controls	NG-FO	Intermediate	--	10	--	--	--	--
Diesel engine trucks	Gasoline	Intermediate	--	35	2,000	6,000	3 yrs.	Switch from gasoline to diesel

1/ Based on data from Jones, H. B., and S. R. Lee, Energy Use and Costs in Broiler Processing Plants in the South, Res. Bul. 205, University of Georgia, Athens, Ga., Oct. 1977; plus other sources [5,6,10,11,18,20,21,22,26,30].

Table 11--Potential energy conservation measures for livestock-meat slaughtering and processing firms, U.S.

Energy saving measures	Implementation time	Potential energy savings	Potential cost-savings	Effect on output	Effect on product price	Capital investment required	Payback period on investment
Reflective coating on roofs over cooled area	S, I	Moderate in L.R.	Small	---	---	Moderate	Varies
Airlocks from warm to cooled areas	S, I	Moderate in L.R.	Moderate	---	---	Moderate	Varies
Heat exchangers to recover waste heat	I, L	Moderate	Moderate	Small	---	Moderate	2 years or less
Boiler blowdown control	I, L	Moderate	Moderate	Small	---	Moderate	2 years but varies
Continuous rather than batch cookers for rendering	I, L	30% less energy	Substantial in L.R.	Could increase	Small	Substantial do remodel or new plant	3-4 years
Insulate valves, pipes, etc. (hot or cold)	S	Small	Small	---	---	Small	1 year
Central heating and air conditioners rather than many small units	I, L	Small to moderate	Moderate	---	---	Substantial	Several years
Lighting - flourescent timers, pilot lights	S, I	20-40% less energy	Small	---	---	Moderate	3-4 years
Use water rather than air cooled refrigeration	I, L	10-15% less energy	Small	---	---	Substantial	Varies
Avoid electricity for heating sources	L	Small to moderate	Moderate	---	---	When replace	Depends on relative fuel prices

slaughtering and processing firms, U.S.

Energy saving measures	Implementation time	Potential energy savings	Potential cost-savings	Effect on output	Effect on product price	Capital investment required	Payback period on investment
Install multispeed fans	S, I	Small	Small	---	---	Small	Varies
Use as few windows as possible	I, L	Heat loss reduced 1/3 or more	Moderate	---	---	---	Varies
Management controls	S, I, L	Moderate	---	---	---	None or small	---
Truck bed building seals at loading dock	S, I	Small	Small	---	---	Moderate	2-3 years
Insulation of hot or cold areas	S, I	Loss reduced as much as 2/3	Moderate	---	---	Substantial	2-3 years
Install heating or other equipment that can use more than one fuel	I, L	Fuel source charge	None, unless need to switch	---	---	Moderate	1 change
Shock Chiller	I, L	10-20% fuel savings	Moderate	Turns product faster	---	Moderate	18 months
Lagoon cover to get methane	I	Save $8500 per year	Substantial	---	---	40,000	6 months
Improving feedwater means less blowdown costs	S, I	Small	Moderate	---	---	Small	1 year or less

Source: Based upon various material from various references.

Table 12-- Potential energy conservation measures for dairy assembly and processing firms, U.S.

Measures	Implementation time	Function cost per unit	Capital investment	Output effect	Payout period	Product price effect	Potential fossil energy savings on function
Milk assembly							
Reorganize collection routes and delivery to plants	Short	Small savings	Small relative to saving	---	NA	Small	10%=3-5 mil.gal. diesel 2-3 mil.gal.gas
Milk processing							
New technology pasteurization (microwave, experimental)	Long (developmental)	Potential	Significant	---	2-5 years	Small	Moderate
Heat recovery-exchange (cooling-heating product & water)	Intermed.	Reduce	Significant	---	2-5 years	Small	Substantial
Water conservation in plant	Intermed.	Reduce	Small	---	2-5 years	---	Moderate
Reconstitution (use concentrated product to supplement fluid supply)	Short Intermed.	Reduce	Small	Debatable	NA	Small Decrease	Significant (transportation)
Fuel substitution by processor	Long Intermed.	Increase Cost	Substantial	Small Negative	NA	Small Increase	Selective substitution
Management controls	Short	Reduce	Small	---	NA	---	Substantial

NA = not available

Source: Based upon material from various references.

possible by improved boiler controls and monitoring practices [19, p.19]. In rendering plants vapor recovery systems could be used to recover exhausted steam vapors from cookers or condensing units resulting in savings of 10 to 20 percent or more [20, p.15]. Other energy savings could be realized if refrigeration compressors used outside air rather than warmer room-temperature air. Using steam turbine drives for refrigeration compressors instead of electricity may also reduce energy use and costs [30, p.37]. This type system resulted in savings of $40,000 annually for a meatpacking firm where mechanical power was about half the cost of electrical power when exhaust heat was applied to the process.

Electricity is used in processing plants in a variety of ways: for ventilating and cooling buildings; operating processing lines and equipment; cooling, refrigerating, and freezing products in various forms; making ice for packing and shipping; and for lighting and supplemental heat. Large quantities are used in ice-making and chilling operations for poultry and in refrigerated coolers and freezers. Plants with on-site waste disposal facilities also use large amounts of electricity. On a BTU equivalent basis, electricity accounts for only 35 percent of energy usage in poultry processing, but accounts for 78 percent of energy costs. Processing plants may therefore have greater incentives to reduce electricity consumption since it will have a significant impact on costs.

Conservation of electrical power can be accomplished in a variety of ways. In the long run the most effective way is in the planning and design of plant facilities. This would involve specification of type and location of equipment and decisions on power outlets, switches, controls, and other factors [19, p.33]. Power substations and distribution panels should be located near load centers to minimize wiring problems and reduce possible voltage drops. Matching voltage and current requirements with rate schedule demand charges can also help minimize costs. Once a plant is built and operating there are fewer opportunities for power conservation. However, certain changes in management practices and alteration of existing equipment could save energy in the short run.

In addition to insulating cold and refrigerated surfaces, as previously mentioned, other ways to conserve electricity include power suppressor controls which would be very useful to minimize peak electrical demand loads for plants [19, p.33]. A combination of power suppressor controls plus scheduling use of major electrical equipment to reduce peak demand could result in savings of 15 percent or more for processing plants. Air compressors, large motors, and refrigeration equipment are the primary items to consider. Many companies now market computerized control systems to balance electrical usage and reduce peak demand loads.

Installation of more efficient lighting systems could also result in substantial energy savings. Flourescent lighting uses about two-thirds less energy than incandescent bulbs and also requires less frequent replacement. Sodium vapor lights are even more efficient than flourescent lights. Savings of $500 per year were achieved in one plant

by installing flourescent lights with an initial capital outlay of only $1,300 [30, p.37]. Use of photoelectric cells or other automated controls for lighting needs could reduce energy consumption even more.

Other methods for reducing electrical requirements would involve use of high efficiency motors or electrical capacitors to improve the power factor levels for motors and equipment. Savings of $450 per year may be possible for a typical plant. Installation of prechilled water systems or cold water regeneration devices that transfer chill water overflows to prechill makeup water in poultry processing plants could also create significant savings in energy use [19, p.33]. Utilizing CO_2 snow ice or controlled atmosphere packaging systems to reduce ice requirements may also reduce energy use in processing plants.

There are many other energy conservation possibilities in the processing sector. Institution of periodic monitoring reports by various departments or segments of the plant could identify problems and create interest and awareness of energy use. Savings of 5 or 10 percent or more could be achieved by these methods [19, p.33]. Controlling ventilation and optimum insulation of buildings could lead to less energy use. Other methods of saving energy include: optimum lighting arrangements with adequate, but not excessive, light intensity at work stations, more frequent and regular maintenance of heating and air-conditioning systems, more energy-efficient equipment, improved building and equipment maintenance, installing central heating plants for groups of buildings, adopting internal energy management programs, loading and unloading trucks inside buildings with doors closed where possible, insulating ovens and cooking equipment, utilizing cooking or oven space more effectively, eliminating downtime on processing lines [30, p.36], installing air locks between warm and cooled areas, using seals between truck beds and buildings at loading docks, and use of continuous, rather than batch-type, cookers for rendering.

If a new plant is being built or major improvements are being made, the plans should be checked carefully for energy conservation factors. In some cases, energy saving techniques will not pay off in existing plants but will in new construction. Solar energy and other energy sources should also be considered for part of the energy needed.

Boilers and other equipment can also be installed which can utilize more than one form of energy for fuel. With dual fired equipment a plant can change fuels when prices or conditions warrant. At current price levels, it is best to avoid electricity for heating sources. Another rule of thumb is that it is almost always better to use water rather than air-cooled refrigeration units.

Transportation

Transportation of animal products involves a wide range of activities including: assembly of products from farms to processing and packing plants; movement of by-products and intermediate bulk meat products to other processing facilities; long distance shipment of products to major consuming markets; and wholesale and retail distribution of these

products to institutions and stores. All of these activities require substantial amounts of gasoline and diesel fuel.

The possibilities for energy conservation in transportation revolve around a number of interrelated factors: interregional production trends, truck sizes and efficiency, driving and hauling practices, density of supply areas, efficiency in route structures, further relaxtion of governmental regulations on backhaul loads, and possibilities of using less energy-intensive modes of transportation (trains and barges). Many of these factors would require long run changes in facilities and practices in order to achieve significant increases in energy conservation. Many processors and trucking companies have shifted to larger trucks with diesel engines which could save 30 to 40 percent in fuel usage [4,39] (Table 13).

Considerable potential for saving energy exists by: improving driving practices, reorganizing route structures, and improving vehicle utilization and performance. Savings of 30 percent or more are possible using a combination of these methods [12,39].

It was estimated that energy costs accounted for 30 percent of total assembly costs for broilers and eggs and 40 percent of assembly costs for turkeys in 1974. About 33 percent of long distance hauling costs were accounted for by energy [30, p.20]. Over 5.2 trillion BTU's of energy were used in 1977 in just the assembly of poultry and egg products alone [1, p.14]. Probably 2 or 3 times as much energy is used in long distance hauling and delivery of poultry products to final outlets.

Meat packing plants have moved closer to production areas over time because it is cheaper to transport meat products than the heavier live animals. The industry has also started cutting the carcass earlier in the channel (boxed beef) so that fewer pounds need to be shipped. Elimination of cross-hauling routes for meat in the U.S. would save substantial amounts of energy. Solution of the cross-hauling problem is not easy, although, as transportation costs increase this practice will probably decrease. Computer routing, shipment consolidation, and improved inventory controls could save substantial amounts of energy. Less energy may be used for some products by using rail shipments, but time enroute is a consideration, as well as convenience and perishability. Containerization, combined with refrigeration equipment, may help encourage more rail transportation.

Potential methods for fuel savings in milk procurement and assembly operations are feasible under a wide variety of production conditions. Processor and producer cooperatives have adjusted procurement operations so as to realize many of the potential savings. Yet, this remains one of the more promising areas for saving petroleum fuel in the dairy industry through coordinated action in a crisis--and the saving could be realized rather quickly. Total fuel costs could be substantially reduced if coordinated suppliers (usually the cooperative) were to handle the procurement and reserve supply functions for all processors in a market area rather than each processor performing his own procurement functions.

Table 13--Potential energy conservation measures in transportation, retailing, and consumption for animal product industries, U.S. 1/

Energy conservation measures	Implementation time	Potential energy savings and/or comments
Transportation		
Improved shipment consolidation	S,I	Substantial savings
Improved inventory consolidation	S,I	Joint or fewer warehouses
Container shipping	I	Ship in boxes or large refrigerated containers
Computer routing of trucks	I	Organize stops, minimize route duplication
Low profile trucks	I,L	Save 7.2% of fuel
Haul heavier loads	S	Save 1.5% for each 5,000 lbs. added
Changing back pressure on truck exhausts from 3% to 1%	S	7% increase in mileage
Increase tire air pressure from 70 to 100 lbs.	S	Increase mileage 10%
Air deflectors over cabs	I	Increase mileage 5%
Strict observance of speed limits	S	Save up to 23%
Fuel additives (special kind)	S,I	Increase fuel effficiency 18%
Oil reclaimer devices	S	To reuse oil, burn in diesel engines
Retail		
Flourescent lights and reflectors	S,I	Alter number and kinds of lights, spacing, reflectors, etc.
Use sensor defrosters for freezers and refrigerators	I	Rather than timed, defrosts only when needed
Install doors on refrigerated display cases	I	Moderate savings possible
Use heat exchangers to capture heat lost from refrigerators	I	Use heat for hot water or heating - 2 year payback

Economizer to cycle off antisweat heaters in frozen cases	S,I	1 year payback possible
<u>Consumers and HRI</u>		
Install energy saving appliances	S,I	Moderate savings
Use microwave ovens	S,I	Uses less energy, doesn't heat up kitchen
Use convection ovens	S,I	Moderate savings
Alter cooking practices	S	Increase food surface exposure by cooking smaller pieces
Consolidate shopping trips or HRI orders	S	Make fewer shopping trips or combine orders

1/ Based upon material from various references

A coordinated supply system minimizes duplication of facilities, pick-up routes, over-the-road transport, risks and costs associated with volume variability due to supply or demand, and reduces competitive differences growing from procurement advantages held by a few. The major criticism of central supply coordination is that processors become dependent upon a single source of milk. Processors in many markets, because of the savings and risk reduction, have opted to turn their procurement functions over to a coordinated supply source. Policy choices will continue to influence this vital aspect of structure in the dairy industry as current debate focuses upon the degree of direct trade-off between efficiency and the reduction in number of competitors on the supply side.

Much discussion has centered upon the extent to which local markets should seek to fulfill their needs for fluid milk with local production. If there is a viable mechanism for efficiently moving supplemental supplies, then neither individual handlers nor markets need carry a reserve to fully meet their own needs at all times. Savings in handling and transportation, both heavy users of fuel, can be effected by supplementing regular supplies with marginal transfers of milk from surplus production areas. This in no way implies shipping a high proportion of milk needs over long distances. Again, realization of the potential saving would require a committment to individual handlers and markets that their needs would be met. Such committment might require some structural readjustment not permitted under current milk order regulations.

Retail Stores

Meat and dairy departments in retail stores use large quantities of energy for refrigeration, but power is also used for lights, saws, wrapping machines, mixers, grinders, and for sanitation purposes. Insulation of refrigeration equipment is important and the use of fluorescent lights and reflectors will also save energy (table 13). Freezers and refrigerators should be equipped with sensors to indicate when to defrost rather than using a timed switch that goes through defrost every 24 hours whether it is needed or not[23]. Store display cases have been a major source of energy loss, as customers realize when shopping in the refrigerated and freezer areas in the store. Display cases with sliding doors may be slightly less convenient for customers, but do save energy. Heat exchangers can also be installed in conjunction with refrigeration equipment to heat water for use in washing and cleaning.

Restaurants, Institutions, and the Home

A substantial amount of energy is used in obtaining, storing, and preparing animal products for consumption. This paper does not stress conservation measures for this category as these have been detailed in other publications. Most livestock, poultry, and dairy products require refrigeration almost to the time of consumption. Additional energy needs for preparing certain foods in the home are low--dairy foods and to some

extent eggs might even be categorized as "energy convenient", as they generally are either ready to serve or require minimal cooking.

New Technologies

Energy can be conserved by making old or current methods more efficient, or by using new ideas and techniques that are developed and adapted over time. A few of these new technologies are shown in table 14. Meat animals can be cut up before they are cooled [27], which decreases the total amount of product that needs to be cooled (bone and trim off), the length of time it needs to be cooled, the amount of time it takes to cool it (several small pieces can be cooled faster than one large one), and, in the case of continuous ham processing, the ham is smoked before it is cooled, meaning that one cooling operation is eliminated.

Other new technologies that could be adopted include chill packing red meat (as is often done in poultry) [24]; frozen meat could also be shipped in insulated bags. An internal heat exchanger using hot water needles, similar to meat tenderizing, could be used to raise meat temperature efficiently before cooking and would tenderize it at the same time. A double singeing and polishing technique has been developed to dehair hogs which does take more space but conserves energy [25].

Another set of innovations relates to processing and packaging meats in such a manner that refrigeration is not needed. In most cases, cooking is minimal or eliminated. These innovations include freeze drying and irradiated meats. Another alternative, retort packaging, is similar to canning meats. Energy is needed at the processing level for these innovations, but probably less than if similar processing (or cooking) were done in the home. These products do not require refrigeration, and cooking is minimal. Overall energy consumed could be reduced with these new processing and packaging methods.

Alternative Energy Sources

From a longer term perspective, there are many alternative sources of energy that might be used to offset the nation's dependence on petroleum based fuels. Some of these alternatives are not economically feasible at the present time, but they may become economical as petroleum products continue to increase in price. Coal is one of the more important alternatives. It can be burned as is, or processed into a gas. The U.S. has large quantities of coal, and production has been increasing in recent years. The disadvantages of coal are its potential for air and water pollution.

Solar energy is also receiving much attention as an alternative energy source. The sun provides tremendous amounts of energy and many applications of solar energy are already in use. Much experimental work is also being done. Solar energy is particularly useful in applications where low level heat is needed. Solar grain drying, water heating, and space heating for homes and processing plants are the most common current uses. Problem areas are the need for large scale collectors and

Table 14--New technologies with potential to save energy in animal products industry, U.S. 1/

Energy conservation measures	Implementation time	Potential energy savings or comments
Hot boning of beef	L	Less cooling required and later saves 50% cooling energy
Chill pack red meat	L	Already used in poultry
Insulated bags or containers for shipping frozen meat or poultry	I,L	Eliminates refrigerated trailers
Continuous ham processing	L	Cut from hot carcass and processed directly without cooling
Internal heat exchange	L	Hot water needles to warm meat before cooking
Double singeing and polishing of hogs	L	Saves energy but takes more space
Mechanically processed product	I,L	Separates meat from bones, poultry uses currently
Retort packaging	I,L	Eliminates refrigeration
Irradiation	I,L	Eliminates refrigeration
Freeze drying	I,L	Eliminates refrigeration
Electronic Halorc	I,L	Energy saving light bulb
Incinerator to turn waste to heat	I	Payback - 3 years
Radiant gas heating systems	I,L	For heating stores and warehouses
Microwave cooking	I,L	In rendering plants or for further-processed products
Ultra high temperature processing for milk	I,L	Delivery and transportation reduced, no refrigeration needed, storable

1/ Based on material from various references.

techniques for storing the heat accumulated during daylight hours. In many instances, solar energy has been used along with conventional backup systems. With more research, solar energy will become more cost-effective and additional usage will occur.

Wind is another source of energy that may have some potential, but more specialized equipment is needed in order to utilize this resource [32]. Certain areas of the country have more wind than others, and thus can utilize or harness wind power better. For many years, wind was used to irrigate and pump water, and it may again become feasible in certain locations. Wind power may even be useful in generating electricity in certain situations.

POLICY CONSIDERATIONS

Public agencies can bring about changes in the food production and distribution system by several different types of policies: some that mandate or require certain changes, and others that encourage or facilitate change by incentives or subsidies. However, agencies could follow a course of passive indifference or possibly even resist or forbid certain changes. This paper assumes that energy usage can be affected by policy applied in the form of price controls, enforced allocation programs, incentives, or by tax reductions or subsidies.

The general responsibility for energy policies in the U.S. is a function of the Department of Energy. Other departments, however, may share certain responsibilities and can contribute to an effective set of policies. Coordinating the development of energy policies that impact upon widely diverse and competing sectors of the economy requires considerable time and negotiation. The Department of Agriculture can aid in developing a satisfactory set of policies to safeguard the Nation's food supply during an energy crisis while making an appropriate contribution to energy conservation.

There will be costs associated with implementing short run changes or adjustments needed to deal with an energy crisis. There is no pretense that fuel conservation policies could be implemented so as to improve the well-being of all participants in society. Some groups undoubtedly will find themselves less well-off as aggregate production-consumption possibilities are lowered by a fuel crisis. The distribution of costs and benefits is an important consideration in any successful conservation program.

Before listing selected policy measures which have the potential to help conserve petroleum-based fuels, perhaps the following comments could serve as guides or considerations to those searching for such policies.

- Energy conservation is a national rather than a state, local, or industry problem. Fuel is transportable, as are the products derived from fuel.

- Sacrifice is needed to conserve energy in a crisis. This sacrifice and cost must be explicitly recognized and dealt with. One of the more serious impediments to the effective use of public policy to conserve petroleum fuels in a crisis situation is the public perception of the situation and of what the Government's role should be. Public acceptance and involvement could help avoid the tendency to delay contingency planning until the crisis develops.

- Energy-saving adjustments require time to implement and to be effective. In fact, some that involve new equipment generally require additional energy to manufacture, deliver, and install before the potential saving can be realized. This type of conservation measure would not be appropriate in a shortrun crisis, but would be extremely helpful to have in place before a crisis developed.

- Policy should recognize those firms which have already vigorously pursued an energy conservation program. It may be quite difficult, costly, and inappropriate for such a firm to realize further reductions. A uniform or proportionate reduction in energy use as a policy may penalize firms during a crisis for having made desirable conservation investments before the crisis. This would tend to discourage the very preventive action which would enable the economy to better weather the crisis if such a policy were adopted.

- Most agricultural commodities have certain critical stages in their production or marketing process. Unless these critical requirements are met, the rest of the process may be for naught. Brooding chicks, refrigerating meat and milk, or delivering the product to market are such examples.

- Allocation of supplies by altering energy prices alone cannot achive maximum social well-being in a crises situation without some loss of stability, equity, or efficiency. Normally, the free enterprise system would depend upon competition, prices, and time to provide efficiency (recognizing that high levels of energy may be substituting for other input and be quite economically efficient). During a crisis, however, rapid adjustment to increased energy prices may not be possible and might suggest direct intervention by Government to direct fuel from fuel-inefficient to fuel-efficient plants or processes. Inequities could be tempered, and responses encouraged, through use of subsidies and incentives.
- There is no single or unique way of making substantial fuel savings. Adjustments in practices, facilities, and management have to be considered together as a complimentary and cumulative process.

- Any effective program must explicitly recognize that there is no known way of meeting an energy crisis without some damage to one or more established levels of production, availability of product,

cost of production, price of inputs, price of products, price stability, profits, access to market, and other characteristics or market relationships.

Short Run Crisis Situation

World conditions have already resulted in periodic shortages in the supply of petroleum-based fuels. In the long run, the U.S. probably can reduce petroleum consumption by adopting conservation measures and using alternative energy sources. In a shortrun crisis situation, however, there will not be time to put the longer run conservation measures into effect.

This section of the report examines possible energy situations and the results that might occur given a short run energy crisis caused by a shortage of petroleum-based fuels. Possible policy measures that could be implemented to lessen the impact of the crisis situation are also presented.

A potential energy crisis can be prepared for ahead of time or it can be dealt with when it occurs. At a minimum there would be a very short time period for taking action. The pipelines and shipping routes for getting petroleum-based fuels to the final user are relatively long. Large tankers carrying petroleum to the U.S. are slow, and several weeks of imports would be "in process" when and if a crisis situation occurred. The U.S. also produces petroleum products which would not be reduced by a foreign supply shortage. Thus, there would be a few weeks to adjust and decelerate use, and the cutback in consumption could eventually reach quantities approaching what the U.S. can produce and obtain from sources other than those cut off by the crisis. Thus far, Congress in its standby authority of gasoline rationing has designated a crisis situation existing when a 20 percent shortfall in the supply of oil occurs [42].

Without prior planning, however, when an impending crisis occurs, the people in the U.S. would immediately try to fill all their tanks and increase inventories for their own use. As a result, the "effects of the shortage " would appear almost immediately. Instead of tapering off gradually, the purchase (not the usage) of petroleum-based fuels may increase markedly during the first week.

Policymakers would thus be in the position of trying to cope with a shortage of supplies and panic buying at the same time. The Department of Energy (DOE) does have plans for implementation in the event of a crisis, but these plans are not generally known, and, thus, DOE would be faced with the enormous task of getting their allocation plans into action and informing the panicked public what these plans are and how they will be administered and enforced. This would create much public outcry and alarm. Prices would probably increase dramatically, not only for petroleum-based fuels, but for all other energy sources also, as substitution among energy sources occurred.

At such a time, the animal products industry would be subject to whatever plan the Department of Energy implemented, with little chance for comment and preparation. Shortages of supplies throughout the production and distribution system would probably occur, resulting in a disruption of supplies to consumers and substantial fluctuations in prices.

If advance planning for a crisis were made, however, it could greatly reduce hoarding and panic; making the crisis much less of a problem. It could also trigger faster adoption of conservation measures if everyone were aware of what type of emergency regulations were planned and what would be expected of individual firms. For example, credit for applying conservation measures prior to the crisis would lead to greater compliance in an emergency situation.

The particular overall plan chosen would have different impacts on the animal products industries. Direct intervention by the government may cause cutbacks in production or changes in prices of animal products depending on how the government intervenes. Some announcement before the crisis of what the intervention procedures will be could reduce uncertainty. If the situation can be partially planned for, panic can be avoided. Prior planning may also provide an opportunity to correct certain inequities in implementing policies.

In the event of a crisis, certain conservation and regulatory measures would be required in the animal products industries. However, if producton were to be maintained at current levels, some fuel might be diverted from other uses and allocated to these industries in certain situations. Another possibility would be to cut production in energy intensive operations for a certan period of time. If whole firms were to shut down, however, there would have to be some way to compensate them.

It could be decided to have price allocate fuel supplies. This would not preclude taxes or other government influence in adjusting relative prices and thus allocation. This could be quite disruptive to the animal products industry because there may be different effects on different stages and/or parts of the animal products industry. Temporary supply disruptions could occur. Allocation by price would likely drive some marginal firms out of business.

If the short run energy crisis resulted in a decrease in production of animal products in order to save energy, the question arises as to whether energy usage would have to be increased in the production of other foodstuffs. An overall energy policy must provide adequate food.

Preparation for long run changes in energy use and changes due to short run crisis, though somewhat different, may be complimentary. If a crisis doesn't occur, conservation measures can be implemented at the most appropriate and economically convenient time. If a crisis does occur, what needs to be done is known and only the time schedule changes. By choosing to be prepared, policymakers can not only plan, but educate and inform the public, so that priorities can be established and reviewed, and inequities ironed out before a crisis occurs.

Possible Policy Measures for a Crisis

Planning before a crisis occurs is a very important step in energy conservation efforts. This section lists a number of possible policies and practices that should be considered in case of a short run energy crisis. The public and the animal products industry should be informed of what will be implemented in the event of a crisis so that planning and implementation can commence beforehand. Some of the possible policy measures listed are very specific for the animal products industry, while others could also pertain to other industries and the public sector. Since implementation should begin early, rather than waiting for a crisis, some measures considered can be longer-run in nature. Selected policies for consideration are:

- Subsidize producers, marketing firms, and even consumers, in selected areas or activities to encourage and enable them to make desired adjustments.

- Apply selective taxation policy to discourage certain practices, areas, or individual firms which are deemed energy-inefficient.
- Restrict output in certain commodities or processing operations that use relatively more energy.

- Reduce distribution areas and duplication of distribution services by competitors.

- Lower building temperatures and lighting intensity for farms and processing plants.

- Reduce scalding and/or steam temperatures in processing and cooking operations.
- Use passive in-place solar heat methods where possible.

- Reduce number of deliveries and increase the density of delivery routes or order size to stores and institutions.

- Reorganize assembly and distribution truck routes for greater efficiency.

- Use only larger payload trucks and/or most efficient vehicles.

- Establish energy-saving driving practices for all motor vehicles.

- Provide system of back-hauls for long distance shipping of commodities.

- Establish monitoring system to determine potential for and extent of energy savings.

- Insulate and seal buildings on farms and processing plants.

- Insulate both hot and cold equipment in processing and distribution facilities.

- Make fewer, and larger-volume, feed deliveries.

- Cut production for commodities where supplies are relatively plentiful in short run.

- Shift from fuel oil to natural gas, LP gas, coal and/or wood where possible. Some electricity substitution in brooding and other operations may be possible.

- Plans could be outlined to decrease production or output of products to reduce energy use. Each producer could be cut back, or selected operations could be closed temporarily.
- Increase bird densities in poultry houses.

- Use partial house brooding and/or lower brooding temperatures.

- Supplement local supplies of fluid milk with reconstituted milk, reducing transportation of feed and/or fluid milk.

- Centralize manufacturing of reserve supplies of fluid grade milk.

- Use central supply coordination for a milk market.

- Suspend selected provisions of milk marketing orders so as to reduce handling and transportation.

- Encourage or restrict feeder cattle movement to nearest feedlot with available capacity and encourage feeding on farm where produced if grain is available.

- Encourage or restrict slaughter animal movement to nearest packer with available capacity.

- Encourage use of hot boning and boxed beef.

- Utilize education and extension information service to provide technical assistance to producers, processors, transporters, and consumers. On-site demonstrations on farms, plants, stores, and homes could contribute to willingness and ability to adjust at all levels, a most important requirement in realizing savings.

- Provide a clearinghouse at different levels of Government to facilitate the settling of differences among individuals and groups regarding allocations, restrictions, incentives, etc. This could enhance the probability of achieving the savings desired while minimizing the cost or disruption associated with programs to deal with an energy crisis.

The Department of Energy would probably have the function of coordinating and administering crisis preparation and programs if a crisis occurred. The Congress, the Department of Agriculture, and others should provide input into crisis planning. In fact, in the planning process, there should be time to get and weigh people's opinions, and

thus develop a better program than would be possible if forced into action by an emergency.

By deciding on a crisis program and informing the public of this program ahead of time, the different sectors, including the food industry, can be ready when the crisis occurs, thereby alleviating at least part of the potential disruption and hardships.

If a crisis does not occur, the planning for a crisis will not have been futile. Long run plans would have been begun sooner and energy usage can be reduced. By not imposing penalties for past energy saving investments firms are encouraged to conserve sooner.

Policy Considerations for the Farm Bill

The following is a list of those items which policymakers might consider specifically for the 1981 Farm Bill and similar legislation which could improve the capability of the food industry to continue to provide adequate supplies of food while conserving fuel:

1. Finance energy-efficient buildings and equipment, trucks and motor vehicles, and alternative fuel sources at lower than market rates through traditional agricultural lending agencies such as Farm Credit Administration, Farmers Home Administration, or Agricultural Stabilization and Conservation Service.

2. Provide subsidies or grants for the design and development of more energy-efficient buildings and equipment in production and processing operations. Agricultural agencies in cooperation with DOE could administer such programs.

3. Provide extra income tax credits for installation and adoption of energy-efficient equipment and methods of production on the farm and in the marketing process. This would have to be part of the Internal Revenue Service tax laws.

4. Deregulate existing ICC controls on mandatory truck routes and eliminate remaining backhaul regulations to allow the food industry to more fully utilize truck capacity and use the most effective route structures.

5. Require ICC to use a "cost of service" concept for establishing railroad grain rate structures rather than "value of service" concept. This more flexible type rate structure would be applicable to other commodities also.

6. Provide a system for energy audits and technical assistance in agricultural production and marketing operations to be conducted by traditional agricultural agencies such as ASCS, Agricultural Extension Service, or others with wide-spread field offices. Financing would be paid by Government.

7. Encourage additional research and development by private agencies and by traditional research agencies in agriculture, primarily land grant colleges and experiment stations, Agricultural Research in SEA, and Economics Research in ESS.

References

(1) Barton, John A., Transportation Fuel Requirements in the Food and Fiber System. Agric. Econ. Report 444, ESCS, U.S. Dept. of Agriculture, Washington, D.C., January 1980.

(2) Barton, John A. and Thomas J. Lutton, Energy Accounting in the Food Processing Industry. ESCS-51, U.S. Department of Agriculture, Washington, D.C., April 1979.

(3) Benson, Verel W., A Guide to Energy Savings for the Poultry Producer, U.S. Department of Agriculture and Federal Energy Administration, Washington, D.C., June 1977.

(4) Burnham, Frank, "The 1980's, Decade of the Diesel," Render, February 1979.

(5) Combes, Richard S., "Scalder Heat Recovery Saves Energy at Mar-Jac," Poultry Processing and Marketing, February 1978.

(6) Combes, Richard, and William Boykin, "Heat Recovery Saves U.S. Processor over $4,000 per Month," World Poultry Industry, June 1980.

(7) Copeland, Randall C. and Bill R. Miller, An Appraisal of Refrigerant Heat Exchanger Technology as Investment Potential in Georgia Dairies, Res. Bul. 254, Univ. of Ga., Athens, Ga., October 1980.

(8) Council for Agricultural Science and Technology, Energy Use in Agriculture: Now and for the Future, Report No. 68, August 1977.

(9) Davis, G.A. and L.J. Connor, A Simulation Study of Decision Strategies for a Hog Processing Plant Constrained by Energy Supply Regulation, A.E.R. No. 326, Michigan State University, East Lansing, Michigan, August 1977.

(10) Dearborn Chemical Corporation, "Energy Savers," Meat Industry, June 1979.

(11) Dixon, John, "Here's How to Cut Energy Costs in Six In-Plant Areas," Broiler Business, May 1977.

(12) Eldridge, Charles, "Energy Conservation in Agricultural Transportation," Economic Issues, No. 36, Dept. of Agric. Economics, University of Wisconsin, Madison, Wisconsin, August 1979.

(13) ERS, USDA, Energy and U.S. Agriculture: 1974 Data Base, Volume 1 and Volume 2, FEA, and USDA, Washington, D.C., September 1976 and April 1977.

(14) Federal Energy Administration, A Study of Energy Conservation Potential in the Meat Packing Industry, November 1976.

(15) Frank, Gary G., A Guide to Energy Savings for the Dairy Farmer, U.S. Dept. of Agriculture and Federal Energy Administration, Washington, D.C., June 1977.

(16) Hansen, Paul, "Energy," Feedstuffs, January 14, 1980.

(17) Hansen, Paul, "Finishing Results Comparable With Shelled or Dry Rolled Corn," Feedstuffs, June 16, 1980.

(18) Hayes, Jack, and John Spradling, "Perdue, Inc. Achieves Fuel Savings of Over $11,000 per Year with Heat Reclamation" Broiler Business, May 1976.

(19) Jones, Harold B. Jr. and S.R. Lee, Energy Use and Costs in Broiler Processing Plants in the South, Research Bulletin 205, University of Georgia Agricultural Experiment Stations, Athens, Ga., October 1977.

(20) Jones, Harold B. Jr., Energy Use and Costs in Poultry Rendering Plants in the South, Research Bulletin 248, University of Georgia Agricultural Experiment Stations, Athens, Ga., January 1980.

(21) Lloyd, W., "How to Save Energy in a Meat Plant," Meat Industry, February 1976.

(22) Lowry, James F., and Richard Combes, "3¢ Energy Cost per Bird Can be Reduced 15-40%," Broiler Industry, January 1976.

(23) Machiaverna, Antoinette, "Energy Control System for Frozen Food Cases Gives Red Owl Payback in less than 10 Months," Supermarketing, October 1977.

(24) Meat Industry, "A Harder Look at Energy Savings," Sept. 1979.

(25) Meat Industry, "Double Singeing and Polishing of Hogs Results in Savings on Gas Usage," June 1980.

(26) Morris, Dale, "Energy Savings as Important as Clocking-In at Mar-Jac," Broiler Industry, March 1976.

(27) Nicholas, Mary Ellen, "Beef Hot Processing Cuts Costs," Agricultural Research, SEA, U.S. Dept of Agriculture, Jan-Feb 1980.

(28) Pearse, Tom, "Boise Businessman to Purchase Hydride Fuel at 50 cents a Gallon," The Drovers Journal, March 13, 1980.

(29) Reis, Kenneth M., "Find Ways to Save Energy or Face Competitive Disadvantage," The National Provisioner, July 5, 1980.

(30) Rogers, G.B., V.W. Benson, and D.L. Van Dyne, Energy Use and Conservation in the Poultry and Egg Industry, Agric. Economic Report 354, Economic Research Service, U.S. Dept. of Agriculture, Washington, D.C. October 1976.

(31) Smith, Rod, "Converting to Fluorescents Could Save Energy Use, Costs," Feedstuffs, July 14, 1980.

(32) The Drovers Journal, "Wind Power-Drawing Energy from Nature", February 1980.

(33) The National Provisioner, "AMI Describes How Meat Plants Have Saved Energy," February 5, 1977.

(34) The National Provisioner, "More Suggestions on How to Save Energy - From AMI Task Force," February 12, 1977.

(35) The National Provisioner, "Study Shows Most Plants Waste Large Part of Energy Paid For," Sept. 13, 1980.

(36) Torgerson, David and Harold Cooper, Energy and U.S. Agriculture: 1974 and 1978, Stat. Bul. No. 632. ESCS, U.S. Department of Agriculture, Washington, D.C., April 1980.

(37) Trevis, Jim, "Ventilation is Key Factor in Reducing Energy Costs," Feedstuffs, Sept. 29, 1980.

(38) Trotter, W.K., W.G. Heid, Jr. and R.G. McElroy, Solar Energy for Agriculture--Review of Research. ESCS-67, U.S. Dept. of Agriculture, August 1979.

(39) Tuten, Robert T., "How Holly Farms Keeps Trucking With Less Fuel," Broiler Industry, March 1976.

(40) U.S. Congress, House of Representatives. National Energy Conservation Act, H.R. 5037. Ninety-fifth Congress, 2nd Session, Nov. 9, 1978.

(41) U.S. Congress, House of Representatives. Natural Gas Policy Act of 1978, H.R. 5289. Ninety-fifth Congress, 2nd Session, Nov. 9, 1978.

(42) U.S. Congress, Senate. Emergency Energy Conservation Act of 1979, S. 1030. Ninety-sixth Congress, 1st Session, Nov. 5, 1979.

(43) Van Arsdall, Roy N., A Guide to Energy Savings for the Livestock Producer, U.S. Department of Agriculture and Federal Energy Administration, Washington, D.C., June 1977.

(44) Van Arsdall, R.N., Thomas and Patricia Delvin, Energy Policies: Price Impacts on the U.S. Food System. Agric. Econ. Report No. 407, ESCS, U.S. Department of Agriculture, Washington, D.C., July 1978.

(45) Ward, Gerald M., "Energy and Resource Requirements for Beef Cattle Production," Feedstuffs, Dec. 20, 1976.

(46) Ward, Gerald M., Resource Requirements of Alternate Beef Production Systems (Annual Report - NSF Grant), Colorado State University, July 1977.